Vitis **52** (4), 207–208 (2013)

Research Note

Does soil temperature restrict outdoor viticulture in southern Finland?

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K e y w o r d s : Nordic viticulture, planting depth, soil temperature, soil freezing.

Introduction: Grapevines have been grown in greenhouses in Finland for 230 years (Justander 1786) and, the grapevine thus is not a newcomer to Finnish gardens. The grapes grown in greenhouses were used for decorating banquet tables or were eaten directly, but they were not used to make wine. In the 1900´s grapes began to be grown experimentally outdoors in southern Finland, at latitudes of 60-63 °N (Reuter 1914, Meurman 1957). The hybrid grape varieties used for the experiments coped well with the cold winters, but they did not have enough time to ripen during the short growing season. In Nordic countries and other cool regions a long winter and the possibility of superficial soil frost can damage the root system of grapevine and delay the beginning of spring growth (Gustafsson and Mortensson 2005, Zang *et al.* 2007).

Modern grapevine breeding has produced numerous cold-resistant and rapid-ripening hybrid varieties, e.g. 'Rondo' (('Précoce de Maligre' x *Vitis amurensis)* x 'St Laurent') and 'Solaris' ('Seyve Villard 5276' x ('Riesling' x 'Pinot Gris')) x ('Zarya Severa' x 'Muscat Ottonel'). Both are suitable for growing outdoors in the Nordic countries. Additionally, global warming promises to improve the climate for Nordic viticulture. In Finland during the last 100 years the annual average temperature has risen approximately by + 1 °C (Tietäväinen *et al.* 2010). In northern Sweden, the annual average air temperature is forecasted to rise + 4.8 °C during next 100 years (Mellander *et al.* 2005) based on SWECLIM (The Swedish Regional Climate Modelling Programme) scenarios.

In addition to air temperature, sunshine hours, temperature sum of growing season, and growing place, soil temperature has an important effect on grapegrowing in outdoor viticulture. The aim of this study was to measure soil temperatures at different depths in Southern Finland (Tuusula and Jokioinen), and in Central Finland (Maaninka and Vehmersalmi) to survey an optimal and safe planting depth for grapegrowing at latidutes of 60-63 °N. Simultaneously with changes of soil temperatures, observations of the growth cycle of grapevine were made in Tuusula, Helsinki-Vantaa region at a latitude of 60 °N.

Material and Methods: The soil temperatures in Southern Finland (Tuusula and Jokioinen) and Central Finland (Maaninka and Vehmersalmi) were monitored year-round in 2007 on the ground surface at 0 cm, and in the soil at depths of 20-70 cm. In 2007 the length of the growing season was exceptionally long and the snow layer thin. In Southern Finland the growing season was 205 d and snow layer persisted only few weeks. The thermometers (waterproof in/outdoor max/min thermometer with hygrometer, manufactured by Shenzhen Hong Tong Yuan Technology Ltd, C5, Jihua Road 399, Bantian town, Longgang district, China (Mainland), Guangdong, Shenzhen) used for the measurements were well protected from moisture and they saved continuously max/min soil temperatures. The temperatures (author´s data) were recorded daily. The measurement points of soil temperature were located on a gentle slope facing to south and close to a large lake. The soil was in each locality sandy clay soil (Yli-Halla and Mokma 2001) with high organic matter content of 6-8 % and pH ranging from 5.8 to 6.2. Soil analysis showed that macronutrients K, P and Ca contents were satisfactory, and Mg content was weak. The growth and development of a hybrid grape variety 'Nordica' (*Vitis vinifera* L. x *Vitis labrusca* L.) was followed throughout the growing season in Tuusula simultaneously with the changes of soil temperatures at a depth of 60 cm.

Results and Discussion: It is essential in Southern Finland that grapevine roots stay below soil freezing depth. Therefore the determination of a safe local planting depth is very important. In recent winters, in Southern Finland the thickness of snow layer has been 20-70 cm (Finnish Meteorological Institute 2012). The too thin snow layer increases the risk of soil freezing. The results of this study are presented in Tab. 1. Mean annual soil temperatures at a depth of 20 and 50 cm were almost at the same level. In winter, at a depth of 20 cm slightly lower temperatures than at 40 and 50 cm were measured. At 60 and 70 cm the insulating effect of thicker soil layer kept temperatures higher and more stable than at 20 and 50 cm, and the lowest soil

T a b l e 1

Mean and lowest annual soil temperatures at depths of 0-70 cm in southern and central Finland

Depth cm	Mean °C	Lowest °C	Growing place Name	Location Latitude
0	8.1	-16.9	Tuusula [a]	60º41' °N
20	6.8	-0.7	Tuusula [a]	„
20	6.7	-1.6	Jokioinen [b]	60º49' °N
20	6.5	-0.8	Maaninka [b]	63º09' °N
40	7.4	0.2	Vehmersalmi [a]	62º52' °N
50	6.7	-0.2	Jokioinen [b]	60º49' °N
50	6.5	0.0	Maaninka [b]	63º09' °N
60	7.9	2.0	Tuusula [a]	60º41' °N
70	8.8	2.7	Tuusula [a]	„

The sources of the soil temperature data: [a] author´s data; [b] data of Finnish Meteorological Institute.

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Table 2

Lowest and highest soil temperatures, and annual growth cycle of grapevine in the southern Finland (Tuusula)

Dates	Observations	Grapevine growth stages - the modified E-L system†		Lowest* °C	Highest* °C
		Major stages	E-L number		
May 2	No growth			0.1	6.1
May 12	Buds	4	2	5.9	6.7
May 22	Bleeding			7.6	8.3
June 5	Shoots begin to grow	12	9	6.4	9.1
June 11	Strong shoots growth		12	8.1	9.1
June 13	Inflorescences are forming		15	8.5	10.2
June 30	Flowering begins	19	19	10.4	14.8
July 12	Flowering ends	23	26	13.0	16.2
Sept. 16	The first frosty night			12.9	16.3
Oct. 3	Harvesting ends	38	38	12.8	16.2
Oct. 31	Dormancy of grapevine	47	47	8.4	11.3

†Modified from Eichhorn-Lorenz (E-L) phenonological stage 1977 by COOMBE (1995)
*Lowest and highest temperatures were monitored during successive periods from May 2 to May 12, from May 22 to June 5, etc.

temperature in winter was distinctly above zero. Soil temperatures in Northern Europe at a depth of 40-50 cm are suitable for grapevine planting with a persistant snow layer over the coldest months. In southern regions of Scandinavian countries the long frost periods have shortened, the growing seasons have prolonged, and soil freezing has been shallow. Although in Central Europe any soil freezing exists just in rare cases, the grapevines are planted in many regions practically in the depth of 40 cm.

In the study the relationship between the soil temperatures and growth cycle of grapevine was also inwestigated. According to Tab. 2, growth and development of grapevine was connected closely to changes in soil temperature during the growing season. The weeping and bud-break of grapevine in Tuusula began at soil temperatures + 6 °C to + 8 °C. These are the same vineyard soil temperatures, where weeping appears and buds begin to break in Central Europe (LÖHNERTZ 2006). In Southern Europe weeping and bud-break begins not until at a soil temperature of 10 °C (JOHNSON 1994). These can be caused by adaptation of same grape varieties to various climate and light differences between Southern and Central Europe. The climate of Central Europe is apparently closer to Northern Europe than Southern Europe.

According to this work and practical experiences it can be concluded that the planting depth of 40-50 cm is sufficient in current climatic circumstances anywhere in Central Europe and the southern regions of Nordic Countries. The soil temperature at this depth does not restrict grape growing in Southern Finland and the grape harvest is over when soil temperature is still as high as during the flowering period (Tab. 2).

This work was supported from MAAT grants to doctoral students from the Department of Agricultural Sciences, the University of Helsinki.

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Received March 20, 2013